



# (Polyvinyl Alcohol-Iodine) Bio-Composites and Their Applications

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## ABSTRACT

**Objective:** Films manufacture of poly vinyl alcohol with the addition of Iodine for treating wounds infected with the disease, especially diabetes.

**Methods:** poly (vinyl alcohol)-iodine composites are prepared by adding iodine element with different weight percents (2,4 and 6) to the poly (vinyl alcohol) PVA matrix. As a solution and film states are used to investigate is healing action. Evaluating the healing action is done by applied these solution and films to the injured mice's and the celavix treatment was used for comparing. The antibacterial activity was checked by expose the prepared samples to the action of Escherichia coli (gram negative) and Staphylococcus aureus (gram positive) microorganisms. Agar well diffusion method was used to evaluate the antibacterial action by measuring the inhibition zone diameter.

**Results:** Results showed that I<sub>2</sub> antibacterial ability against both Escherichia coli and Staphylococcus aureus microorganisms and this ability increased with increased I<sub>2</sub> content in both films and solutions states. Complete healing obtains within eight days. UV and FTIR results proved presence of physical interaction between poly (vinyl alcohol) and iodine and the UV parameter will change with I<sub>2</sub> content. Tensile strength, density, wettability, the color degree increased with iodine content.

**Conclusion:**The results show that the drug is antibacterial active and healing wound well.

**Key Words:** PVA, Iodine , Injured mice's, Antibacterial, Microorganisms.

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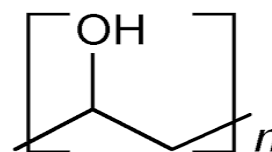
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## INTRODUCTION

Based on its easy arrangement, pure, no virulent, environmentally-safe and bio hugging characteristics, finest chemical strength and visceral properties [1].

Usually, PVA with

hydrolysis of 98.5 % or more advanced perhaps dissolved in spray at 70 °C, that is a popular rehearse for preparation this solution [2]. The formation of polyvinyl alcohol (not wholly dissect) seize in obsessed in Fig (1) [3].



**Figure (1):** chemical structure of poly(vinyl alcohol)

In 2013 S . Muppalaneni and H . Omidian establish PVA polymers and copolymers can show singular wet retentiveness, film forming, vigor and contusion properties, whichever perhaps immensely benign especially hardihood applications, and unusually

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essence use. These materials have also initiate big applications in biomedical filed for the reason that non-toxicity and useful swelling and automatic properties [4]. In 2014 M. Kouchak et al showed sundry mingle films employing chitosan (Cs) and PVA . Addition of nitrofurazon led to fall off toughness, oxygen permatalent (OP), swelling proficiency (SW) of Cs films, while elevated wet steam automatic transmission rate (WVTR)[5]. In 2015 R. Kakkar et alia showed the use of silvery nanoparticles in silvery leak dressings and in executive of infected traumatizes import, as special pathogenic germs have advanced struggle vs different antibiotics [6]. Iodine (I<sub>2</sub>) form Group 17 of the Periodic Table, the halogen, and thus shares many of the common characteristics of the elements included arrange, like high electronegativity (2.66 to the degree that the Pauling mount) [7]. Drug resistance to pathogenic bacteria has led to an alarming situation worldwide due to the development of antibitotic resistance genes against current antibitotics . Misuse and overuse of antibiotics have led to new resistance patterns in several bacteria and the WHO focuses on control and prevention of such antibiotics. Multi-drug resistant (MRD) such as metallo-beta-lactamase (MBL) and methicillin-resistant Staphylococcus aureus (MRSA) bacteria is rapidly evolving causing an emerging threat to the community [8] . Wound can be defined as any process which leads to the disruption of the normal architecture of a tissue. They may be closed or open, e.g. abrasions, lacerations, avulsions, ballistic and excised, or surgical wounds. Open wounds are by far the most common and are characterized by a break in the skin[9]. Wound curing is the appeal of interactions by the whole of cytokines production factors, consanguinity and the extracellular grid[10].

## 2. EXPERIMENTAL PART

### 2.1 MATERIALS

Poly(vinyl alcohol) was purchased from Verdean house , Daryaganj , New Delhi-110002 (India) with the properties degree of hydrolysis (86.0 -89.0 %) , M.W.=85,000 to 1,24,000). Iodine was purchased from Merck (Darmstadt, Germany).with the properties Density = 4.93 g.cm<sup>-3</sup> at 20°C Melting point at 114°C.

### 2.2 Preparation of PVA/Iodine film

PVA/Iodine films were prepared by casting method by mixing PVA solution with I<sub>2</sub> solution. PVA solution was prepared by dissolving (1g) PVA powder in 40 ml distilled water (DW) with continuous stirring for 15 min in 70 °C .Iodine solution was prepared according to the following procedure :grinding the iodine molecules to powder, adding I<sub>2</sub> powder to DW by 2,4and6 wt.% ratios and leaving these solutions for three hours in sealed glass container at the room temperature (RT).

### 2.3 Tests

To Determinate of antibacterial activity, Muller Hinton agar plates (Agar Well Diffusion Method) were

prepared and inoculated with test organisms (Escherichia coli , staphylococcus aureus)by spreading the inoculums on the surface of the media with the help of sterile swab. [11]. FTIR test was carried out using (IRAFFINITY-1) (Shimatzu ) to check the structure of polymer . The spectral absorption of iodine solution is done by UV-Vis double beam spectrophotometers, (SHIMADZU, UV-1800, Japan) . All spectra were measured at room- temperature in a quartz cell with a 1 cm optical path length. Wettability test achieved by using is SL 200C - Optical Dynamic I Static Interfacial Tensiometer & Contact Angle Meter which manufactured in KINO Industry Co., Ltd., USA with contact angle range from 0° to 180°. Tensile Test was performed by using (Bongshin model WDW-SE) instrument. The tensile device applies load range (1-50KN) with speed range (0.1-50 mm/min).

## 3. RESULTS AND DISCUSSION

### 3.1 Antibacterial action:

were be used for each samples. Every sample was undergo to activity to Escherichia coli (E-coli) and Staphylococcus aureus (staphella) microorganisms as shown in figure (2). It is clear that pure I<sub>2</sub> is very active in inhibition the growth of both E-Coli and Staphella microorganisms, where the inhibition zone are 20mm and 20.5 mm respectively for I<sub>2</sub> solution (table 1). In contrast, pure PVA have no activity in inhibition the growth of both the two organisms (inhibition zones are zero). For 2 wt.% I<sub>2</sub> solution mixture, the inhibition zne increased from 0 to 20.5mm with E-Coli microorganism and from 0 to 30 mm Staphella microorganism. Similar increased happened for 2 wt.% I<sub>2</sub> film mixture where the inhibition zone increased from 0 to 10 with E-Coli microorganism and from 0 to 20 mm Staphella microorganism. With increasing I<sub>2</sub> content in both solution and films, the inhabitation zones increased, which indicate that I<sub>2</sub> have good ability to inhibit the growth of these microorganisms. This is clear from the diameters of inhibition zones, where the diameter increased to 30.5 mm in 4 wt.% I<sub>2</sub> mixture with E-Coli microorganism. Similar behavior occur with staphella microorganism where the diameter increased up to 4 mm for the 6 wt.% I<sub>2</sub> mixture . The behaviors were occur in mixture films where the diameter increased up to 4 mm for the 6 wt.% I<sub>2</sub> mixture with both the two microorganisms.

Figure (3) the effect of PVA/I<sub>2</sub> film on the health of injured mice , were mice were divided in three groups( each group with five mice) to monitor this effect. The first group (a) considered as negative control (without treatment) and the second group (b) as a positive control with celavix drug, while the last three group (c) PVA/I<sub>2</sub> mixtures which added to the injured mice. The addition of PVA/I<sub>2</sub> mixtures done to mice by 2, 4, 6 wt.%, while figure (3) shows only the 6 wt.% ratio because it is the best ratio in healing the wounded mice. The healing tendency for all samples was monitored daily by taking photos. The wounds

treated by celavix drug as shown in photo (b) and the wound treated by PVA/I<sub>2</sub> mixture shown in photo(c).

On the second day, there was an improvement in the healing treated treatment of wounds especially those treated with PVA/ paste as shown image (c), while the animals without treatment (negative control) showed no healing improvement, the wound still wet, redness and there is some coagulation as shown in image (a). On the fifth day after the treatment, the images showed that the wound treated

with PVA/I<sub>2</sub> looked smaller and the wound healing was better and the skin returned to its normal color, light pink to in picture (c), while the wounds appeared in the animals group of B are still in the coagulation stage despite of the using of a disinfectant wet as well as with the animals in the untreated group (figure a).

In the eight, complete healing of the wound is appeared as shown in photo (c) and the skin return to its nature, other groups still in coagulation phase as shown in photos (a) and (b).

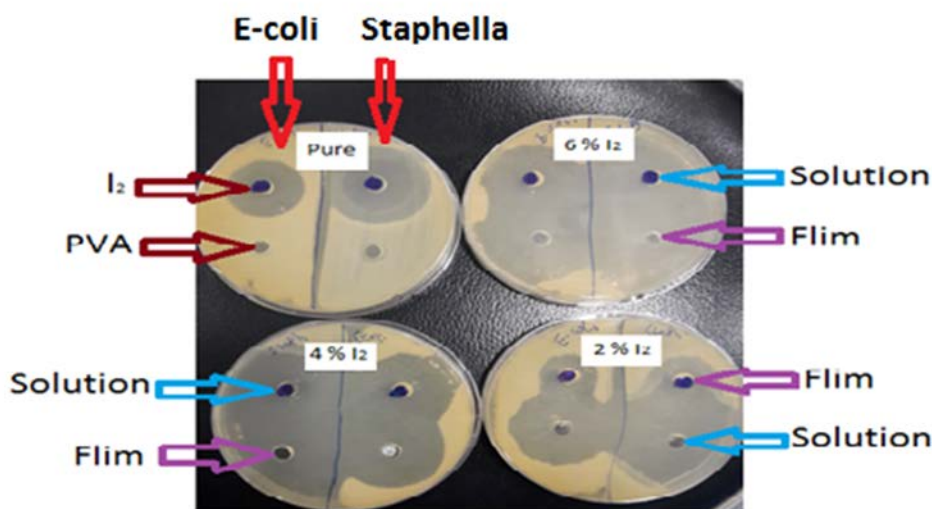
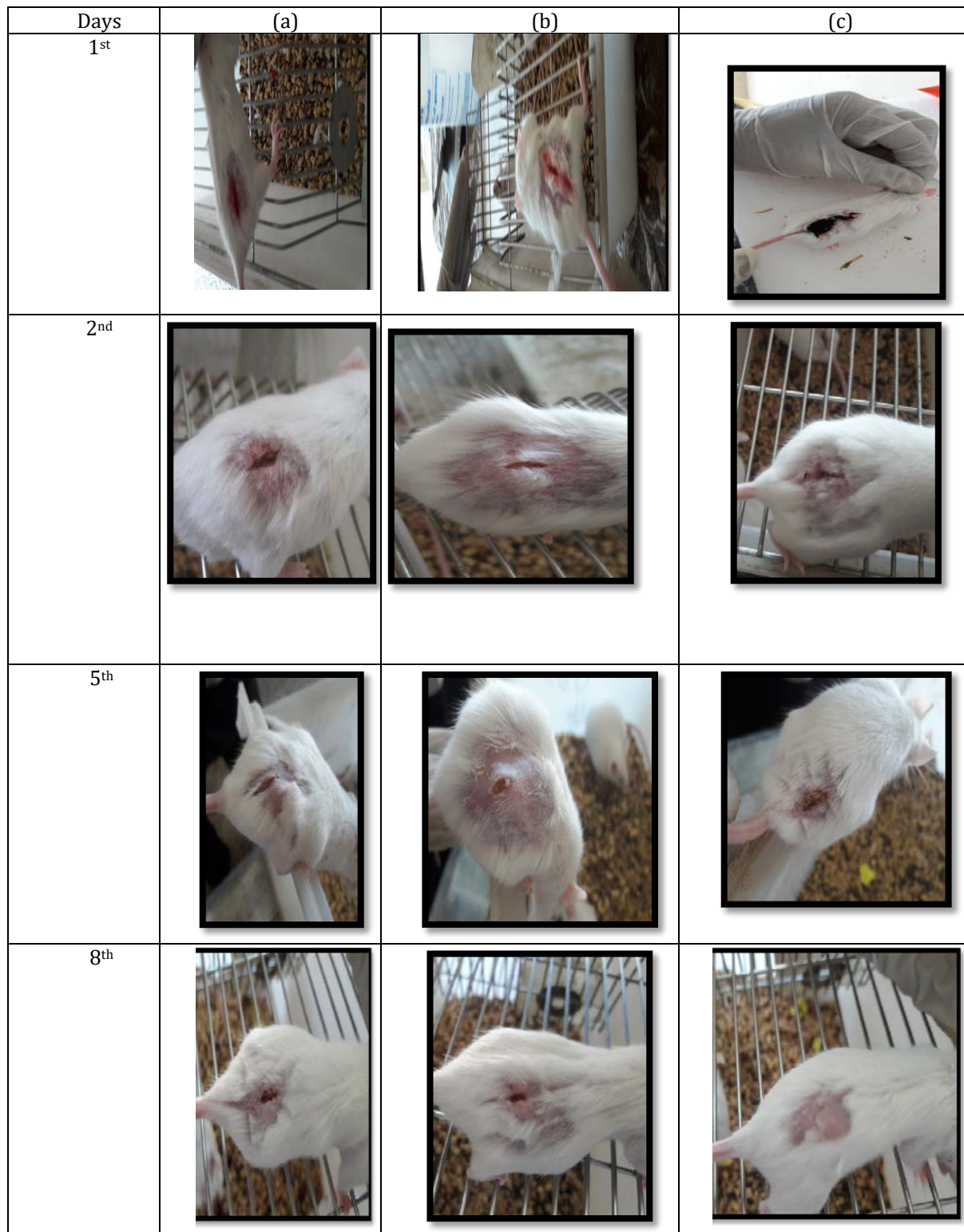


Figure (2): Antibacterial for pure I<sub>2</sub> , pure PVA and (PVA-I<sub>2</sub>) Composite.

Table 1: inhibition zone for pure I<sub>2</sub> ,pure PVA and its composite

Sample	Microorganism type		Inhibition zone diameter(mm)		Sample state
	STOPH	E-COLI			
Iodine	STOPH	E-COLI	20.5	20	Solution
Pure PVA	STOPH	E-COLI	0	0	Solution
2 wt. %	STOPH	E-COLI	30	20.5	Solution
	STOPH	E-COLI	20	10	Film
4 wt. %	STOPH	E-COLI	3.5	3.5	Solution
	STOPH	E-COLI	40	30.6	Film
6 wt. %	STOPH	E-COLI	40	3.9	Solution
	STOPH	E-COLI	40	40	Film



**Figure (3):** The effect of the prepared PVA/ I2 film on the health of injured mice's for (a) control negative (b) control positive (c) treated mice's

### 3-2 UV-Visible Spectra

Figure (4) shows UV-visible the absorbance of the pure PVA ,pure I2 and the prepared films (2%,4% and 6% I2 in PVA matrix ). Result showed there is a blue shifting ; to the higher energy . this due to the donation of electrons from I2 to the PVA, which stabilizes the

PVA towards bacteria, as well as, by this process , I2 activated toward the same target. Such process is called charge transfer. The composite with I2 shows that more shifting than the other percent's, since I2 is large halogen molecule (140 pm) ,which is difficult to

diffuse through the network of PVA as its concentration increases . IR spectra fig(5) show the same behavior (physical interaction)

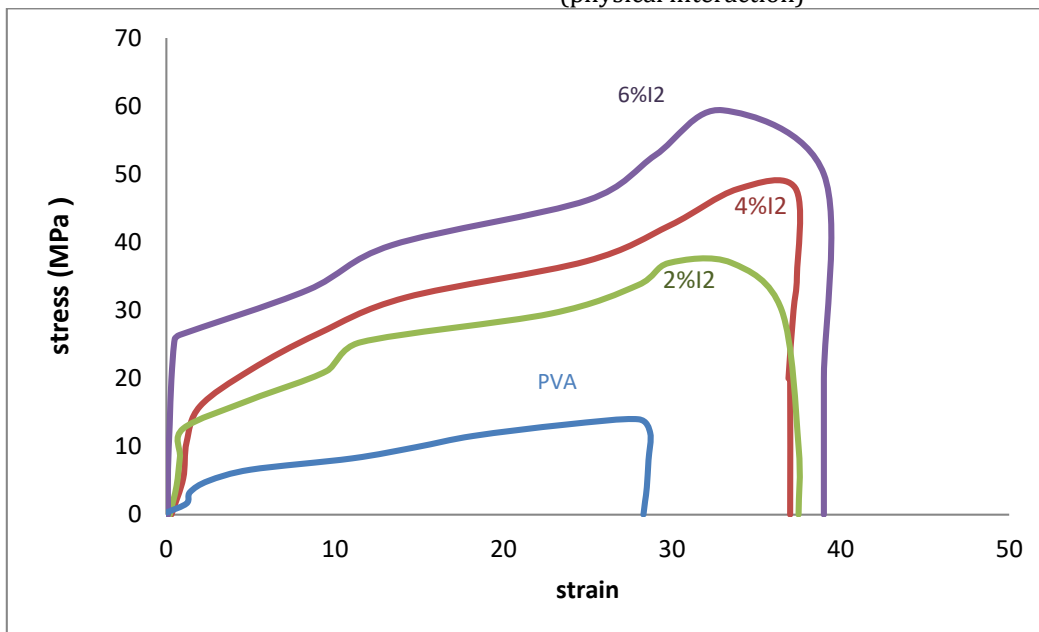


Figure (6) stress-strain curves pure PVA and its composite

### Density test 3-4

Figure (7) shows the behavior of the composite density which is increased as the iodine percent increase. This is due to the high iodine density ~5

g/cm<sup>3</sup> as well as iodine diffusion between PVA chains to fill the vacancy present in the PVA network result in increasing the composite density .

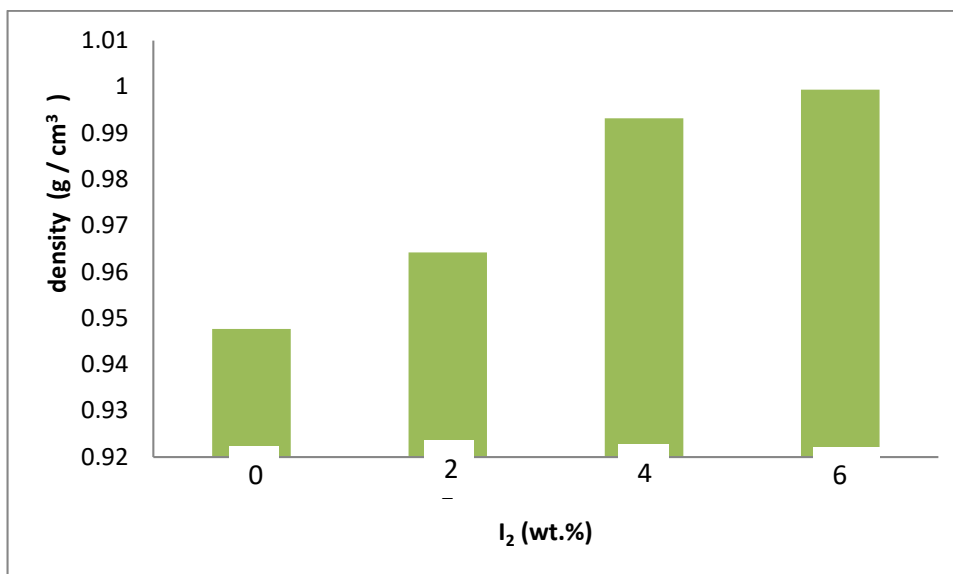
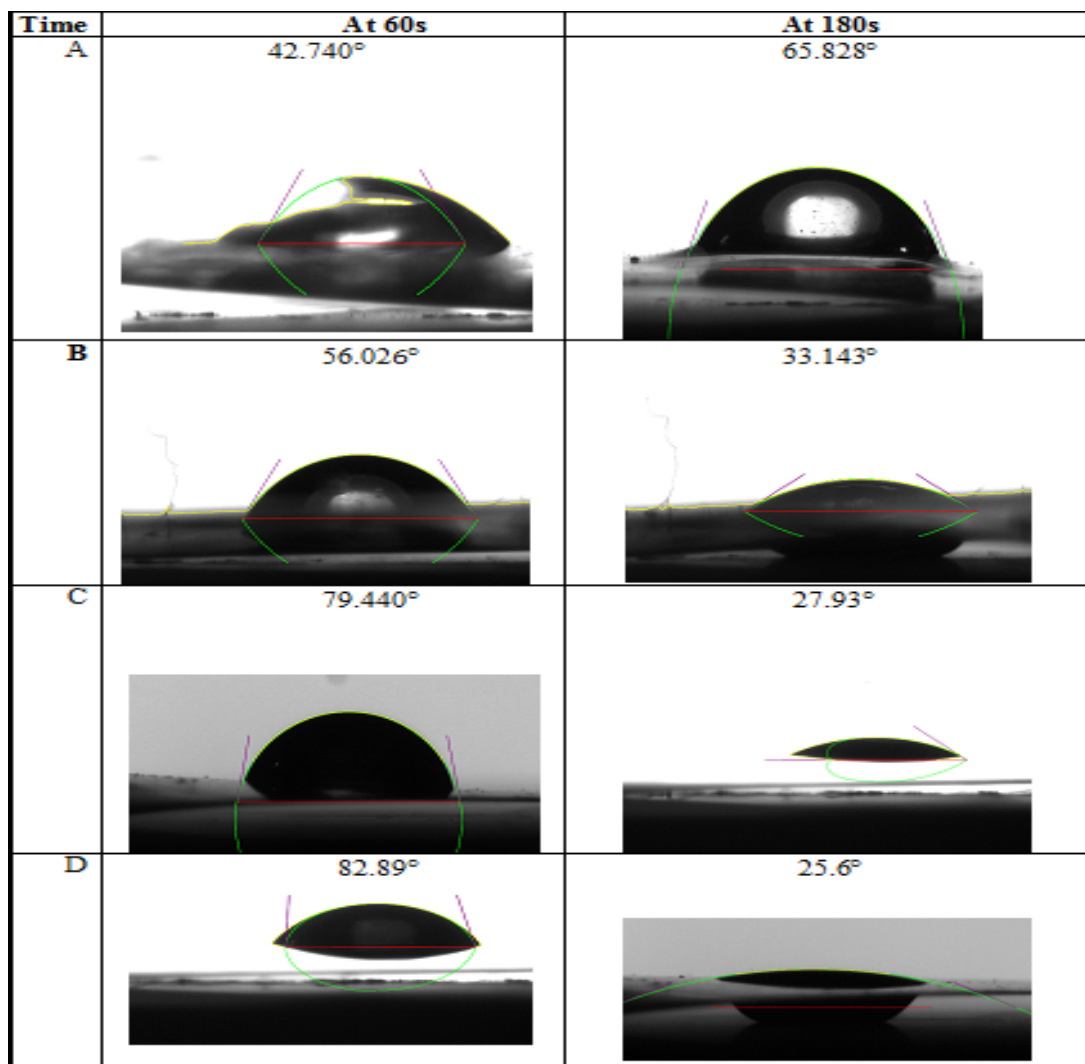


Figure (7) The dependency of density on the I2 content

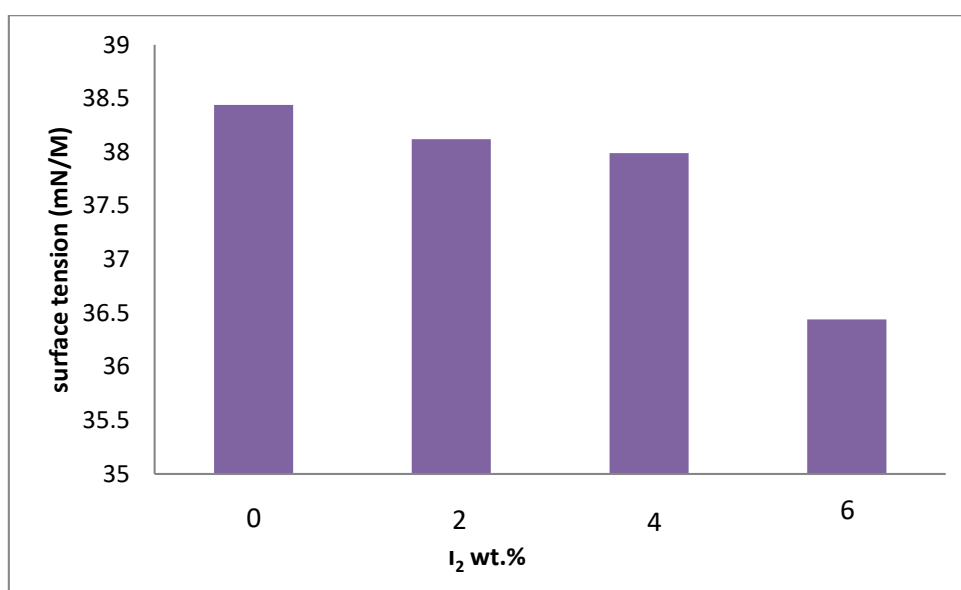
### 3-5 Wettability

Figure (8) show that the wettability of composite is a function of time. In short time (60 s), the behavior of the film is hydrophobic and slowly its absorptivity increased through the diffusion of water molecule in the film and the iodine molecule enhance the diffusion process, which is clear from figure (8),

this figure also shows that wettability increased as weight percent of iodine increased at 180 s. These results are in good agreement with the surface tension results (figure 9), where surface tension decreased as I2 content increased.



**Figure (8):** Contact angles at 60s and at 180s for (a) pure PVA (b) PVA/I<sub>2</sub> film with 2 wt.% I<sub>2</sub> (c) PVA/I<sub>2</sub> film with 4 wt.% I<sub>2</sub> (d) PVA/I<sub>2</sub> film with 6 wt.% I<sub>2</sub>



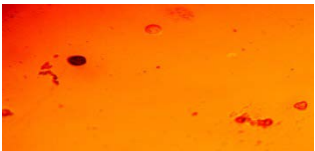
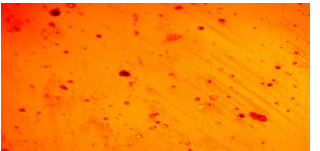



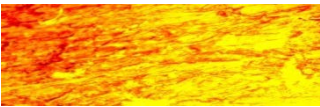


**Figure (9):** Surface tension for (PVA/I<sub>2</sub>) mixtures  
 Optical microscope:3-6

### 3-6 Optical microscope:

Figure (10) show picture with two magnification powers and its composites (2 wt.% I<sub>2</sub>, 4wt.% I<sub>2</sub> and 6wt.% I<sub>2</sub>). Result showed that that addition of iodine

to the PVA film result in coloration of film and the color of the film becomes more degree as well as the magnification increase the distribution of iodine becomes more clear.

	A	B
PVA		
2%I <sub>2</sub>		
4%I <sub>2</sub>		
6%I <sub>2</sub>		

2-

7

### CONCLUSION :

- 1- Iodine have the ability to inhibit the growth of both *Escherichia coli* and *Staphylococcus aureus* microorganisms .As I<sub>2</sub> concentration increased in PVA/I<sub>2</sub> composite, the antibacterial activity increased.The antibacterial activity against *Staphylococcus aureus* microorganism is higher than the *Escherichia coli* in both films and solution stats. The healing action for injured mice's with the prepared films is better than for celavix treatment ,and the complete healing achieved within eight days.
- 3- UV and IR result proved that there is an physical interaction between the iodine filler and PVA matrix .In UV-visible spectra, there is a blue sifting to the to the higher energy .UV-visible parameters (The absorbance, Optical conductivity , The Extinction coefficient ) were affected by the I<sub>2</sub> content.
- 4- Tensile strength , density, The wettability of composite and The color of degree of the film increased with I<sub>2</sub> content.The wettability of composite is a function of time increased as I<sub>2</sub> content increased.

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